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(54) COPPER ALLOY MALLEABLE MATERIAL EXCELLENT IN BENDING WORKABILITY AND METHOD FOR PRODUCING COPPER ALLOY MALLEABLE MATERIAL

(57)Abstract:
PROBLEM TO BE SOLVED: To produce a copper alloy malleable material small in anisotropy and excellent in bending workability.
SOLUTION: The difference in tensile strength between the rolling parallel direction and the rolling vertical direction is ≤30 N/mm2.

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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] Titanium is rolled out to the copper alloy which consists of copper which becomes a under 5.0 mass % implication and a remainder real target more than 0.5 mass %, and an unescapable impurity. Solution treatment and aging treatment are performed, it is manufactured, and the grain size number after the last solution treatment is under 0.035 mm more than 0.005 mm. Copper alloy expansion material characterized by for there having been little anisotropy which has the tensile strength of two or more [800Ns //mm] after aging treatment, and is expressed with the difference of the tensile strength of a rolling parallel direction and a rolling perpendicular direction as [or less / 30Ns //mm] two, and bending nature being excellent.
[Claim 2] The manufacturing method of the copper alloy expansion material characterized by facing performing rolling, solution treatment, and aging treatment to the copper alloy ingot which a under 5.0 mass % implication and the remainder become from copper and an unescapable impurity substantially more than 0.5 mass % about titanium, and manufacturing expansion material, and making the grain size number after the last solution treatment of this copper alloy under into 0.005mmor more0.035 mm.
[Claim 3] The manufacturing method of the copper alloy expansion material according to claim 2 characterized by quenching them with the cooling rate more than a 200K/second after whenever [stoving temperature] heats the conditions of the last solution treatment 10 seconds or more under by 1123K (850 degrees C) more than 923K (650 degrees C) at less than 300 seconds when a continuation heat treatment facility performs solution treatment for the above-mentioned copper alloy.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] If this invention relates to the copper alloy expansion material which consists titanium of a under 5.0 mass % implication, remainder copper, and an unescapable impurity more than 0.5 mass %, and the method of performing rolling, solution treatment, and aging treatment to an ingot, and manufacturing copper alloy expansion material and it states in more detail, an anisotropy will offer the copper alloy expansion material which was excellent in bending nature few.
[0002]
[Description of the Prior Art] Since reinforcement and a stress relaxation characteristic are excellent also in the material property as a copper alloy of an aging deposit mold, especially the copper alloy (henceforth a "titanium copper alloy") containing titanium has been widely used in the field of electronic parts or pole connector components. If an ingot is manufactured by dissolution casting, after performing processing of cold working between heat, heat treatment, etc. after that, performing surface treatment, such as plating, to this copper alloy further about some ingredients and making it into a predetermined property and a predetermined configuration, it is processed into components. The titanium contained in a titanium copper alloy is separated from a supersaturated solid solution, and it is thought that an age-hardening is started by intermediate phase generation to a Cu3Ti phase. It is the features that the titanium copper alloy other than the above-mentioned property is also excellent in thermal resistance compared with high tensile beryllium copper. Therefore, it pierces to a plate and a bar, processing and bending are performed, and it is widely used as electronic parts or a pole connector ingredient.
[0003] On the other hand, especially in case expansion material is manufactured, subsequent workability and a subsequent material property change greatly with solution treatment or aging treatment conditions. In solution treatment, the spinodal decomposition which does not need a nucleation produces the deposit from a supersaturated solid solution, and a property changes with the conditions a lot. If fluctuation of the solute concentration which exists in the interior of an ingredient produces spinodal decomposition, the free energy of a system is lower than the energy as a supersaturated solid solution, and phase decomposition will advance spontaneously and will not form the nucleus of critical size. That is, once small concentration fluctuation arises in an ingredient, it will change to big concentration fluctuation one after another, and will separate into two phases eventually. Although a material property will change a lot if spinodal decomposition happens, this decomposition advances rapidly.
[0004] Therefore, it is necessary to process on the cooling conditions to which dispersion in a property is small, concerning the solution treatment of a titanium copper alloy since subsequent processing not only becoming easy but material property dispersion will become small if an ingredient can be cooled before spinodal decomposition arises after performing hot rolling and solution treatment, and quality is stabilized, and subsequent processing becomes easy. Moreover, in case components processing is carried out after carrying out aging treatment of the titanium copper alloy, it is necessary to lessen an anisotropy and to raise bending nature.
[0005]

[Problem(s) to be Solved by the Invention] However, since it was not grasped whether which factor of effect is conventionally the largest among the production process conditions exerted on an anisotropy, as for bending nature, it was inadequate. According to research and an experiment of this invention persons, it became clear that the grain size number of the ingredient by solution treatment cooling conditions and solution treatment had affected the subsequent material property greatly. In view of the starting point, it succeeds in this invention, and it offers the copper alloy expansion material which lessened the anisotropy and was excellent in the bending nature in the case of components processing.
[0006]
[Means for Solving the Problem] The place made into the summary of this invention is as following.
(1) Roll out titanium to the copper alloy which consists of copper which becomes a under 5.0 mass % implication and a remainder real target more than 0.5 mass %, and an unescapable impurity. Solution treatment and aging treatment are performed, it is manufactured, and the grain size number after the last solution treatment is under 0.035 mm more than 0.005 mm. Copper alloy expansion material characterized by for there having been little anisotropy which has the tensile strength of two or more [800Ns //mm] after aging treatment, and is expressed with the difference of the tensile strength of a rolling parallel direction and a rolling perpendicular direction as [or less / 30Ns //mm] two, and bending nature being excellent.
(2) The manufacturing method of the copper alloy expansion material characterized by facing performing rolling, solution treatment, and aging treatment to the copper alloy ingot which a under 5.0 mass % implication and the remainder become from copper and an unescapable impurity substantially more than 0.5 mass % about titanium, and manufacturing expansion material, and making the grain size number after the last solution treatment of a copper alloy under into 0.035 mm more than 0.005 mm.
(3) The manufacturing method of the copper alloy expansion material characterized by quenching with the cooling rate more than a 200K/second after whenever [stoving temperature] heats the conditions of the last solution treatment 10 seconds or more under by 1123K (850 degrees C) more than 923K (650 degrees C) at less than 300 seconds, when a continuation facility performs solution treatment for the above-mentioned copper alloy.
[0007] Namely, as mentioned above, if the tensile strength after aging treatment is less than [800Ns //mm] two in the copper alloy exhibition **** material which consists of a under 5.0 mass % implication, remainder copper, and an unescapable impurity more than 0.5 mass %, titanium If the anisotropy which reinforcement runs short and is expressed with the difference of the tensile strength of a rolling parallel direction and a rolling perpendicular direction exceeds 2 [30Ns / /] mm The anisotropy became large and the anisotropy which has the tensile strength of two or more [800Ns //mm] in ** in which bending nature is not excellent after aging treatment, and is expressed with the difference of the tensile strength of a rolling parallel direction and a rolling perpendicular direction to it in this invention limited or less [30Ns //mm] with two. The isotropy of this outstanding expansion material and high intensity are not obtained by the conventional material, and this is related to the grain size number (grain size number after the last solution treatment) of a medium process. In addition, a final grain size number does not have serious effect on an anisotropy, although it fluctuates somewhat to the grain size number of a medium process under the effect of processing of an after process.
[0008] Next, when the property excellent in reinforcement etc. will not be acquired if the addition of titanium becomes under 0.5 mass %, but it became more than 5.0 mass %, in this invention, titanium was used as copper and an unescapable impurity at the remainder real target under including 5.0 mass % more than 0.5 mass %, because the ingredient which the ingredient hardened and was excellent in workability was not obtained. In addition, in addition to titanium, the same effectiveness is expectable even if it adds the chromium below 1.0 mass %, a zirconium, nickel, iron, etc. in a total amount. The grain size number after the last solution treatment of this copper alloy was set to 5 micrometers or more less than 35 micrometers because the effect of front processings, such as cold working, remains if a grain size number becomes under 0.005 mm, it is because expansion material with sufficient working characteristic is not obtained, an anisotropy became large in case components processing will be carried out, if this grain size number becomes more than 0.035 mm, and bending nature was remarkably

inferior.

[0009] Moreover, when performing solution treatment using a continuation heat treatment facility, after whenever [stoving temperature] heats the conditions of the last solution treatment 10 seconds or more under by 1123K (850 degrees C) more than 923K (650 degrees C) at less than 300 seconds, it is desirable to quench with the cooling rate more than a 200K/second. Control becomes difficult in order not to obtain the above-mentioned grain size number even for heating for 300 seconds or more as whenever [stoving temperature] is under 923K (650 degrees C), but to carry out grain growth shortly after reaching the temperature as it is more than 1123K (850 degrees C), and to obtain the ingredient of the above-mentioned grain size number. Furthermore, the cooling rate after solution treatment was carried out for spinodal decomposition arising and an ingredient hardening at the time of cooling, to more than the 200K/second, when it cooled with the cooling rate of under a 200K/second. In addition, it is obtained by cooling by water cooling or the air-water fuel spray in order to attain the cooling rate more than a 200K/second.

[0010]

[Function] According to this invention, if the grain size number after the last solution treatment of a titanium copper alloy is made under into 0.035 mm more than 0.005 mm, the anisotropy at the time of carrying out components processing will be lessened, and it will become possible to offer the ingredient which has the property which was excellent in bending nature.

[0011]

[Example] The component of the titanium copper alloy which did predetermined mass % content of the titanium used as a test specimen is shown in a table 1. 3.5kg (30mmtx120mmwx100mml) of ingots of the titanium copper alloy blended with the predetermined component is ingoted within a vacuum melting furnace, and surface peeling is performed after cutting the feeding head section. thickness (usually 8mm thickness) predetermined from 27mm thickness after the peeled ingot performs homogenizing annealing by 1123K (850 degrees C) in atmospheric air for 1 hour -- until -- it hot-rolls. During rolling, whenever [material-list surface temperature] was measured with 2 color type emission pyrometer, and water cooling was carried out in the place which became predetermined temperature.

[0012]

[A table 1]

試験に用いたチタンを所定質量%含有した銅合金の成分

		成分（wt%）	
		Ti	銅
1	チタン銅 ①	1.5	残
2	チタン銅 ②	3.0	残
3	チタン銅 ③	4.5	残
比較			
4	チタン銅 ④	0.4	残
5	チタン銅 ⑤	6.0	残

[0013] Although titanium copper ** which is a comparison alloy went to the last aging treatment, the property (tensile-strength 800 N/mm2, 2% or more of elongation) needed was not acquired. The crack generated titanium copper ** which is a comparison alloy on the occasion of hot rolling, and subsequent processing became difficult.

[0014] Furthermore, after carrying out solution treatment by 1173K (900 degrees C) for 1 hour, surface hide shaving is performed again and it is made 1.0mm thickness from 7.5mm thickness with cold rolling. Next, predetermined time heating was carried out at predetermined temperature using the equipment which can change heating and a cooling rate into arbitration, the last solution treatment cooled on various cooling conditions was performed, and it evaluated according to the grain size test approach (JIS H0501) of a copper elongation article after that. Furthermore, it cold-rolled to 0.3mm of

stock thickness, and aging treatment was performed by 673K (400 degrees C) for 4 hours. In addition, the material temperature under heat treatment equipped the heat treatment part of an ingredient with the thermocouple of a contact process, and measured the material temperature under trial continuously, and various cooling rates were performed by adjusting water cooling, the sea-mingled-with-fresh-water fuel spray, the amount of water of air cooling, and a quantity of gas flow. Then, while carrying out the tensile test of parallel and a perpendicular direction to rolling of an ingredient and investigating the anisotropy, the bending test estimated bendability repeatedly.

[0015] The last heat treatment conditions of a test specimen are shown in drawing 1 (table 2). Moreover, the test result which performed the tensile test and the flex test is shown in drawing 2 (table 3). A tensile test shows the average of N= 3. Bend radii of R= 0.3mm estimated 90-degree flex test by the count to fracture (0.3mm of board thickness). "Fracture" in a table was fractured by the 1st bending. By the approach manufactured in this invention, the anisotropy was small and became possible [manufacturing this copper alloy that was excellent also in repeat bendability] so that more clearly than a table 3.

[0016]

[Effect of the Invention] According to this invention, an anisotropy becomes it is small and possible [manufacturing this copper alloy that was excellent also in repeat bendability].

[Translation done.]

JAPANESE [JP,06-248375,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD EFFECT OF THE INVENTION TECHNICAL PROBLEM EXAMPLE

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(54)【発明の名称】　曲げ加工性が優れた銅合金展伸材及び銅合金展伸材の製造法

(57)【要約】
【課題】　異方性が少なく曲げ加工性が優れた銅合金展伸材を提供する。
【解決手段】　圧延平行方向と圧延垂直方向の引張り強さの差が３０Ｎ／ｍｍ²以下である。

【特許請求の範囲】

【請求項１】　チタンを0.5質量%以上5.0質量%未満含み、残部実質的になる銅及び不可避不純物からなる銅合金に圧延、溶体化処理及び時効処理を施して製造され、最終溶体化処理後の結晶粒度が0.005 mm以上0.035 mm未満であり、時効処理後８００Ｎ/ｍｍ²以上の引張り強さを有し、圧延平行方向と圧延垂直方向の引張り強さの差で表される異方性が３０Ｎ/ｍｍ²以下と少なく、曲げ加工性が優れたことを特徴とする銅合金展伸材。

【請求項２】　チタンを0.5質量%以上5.0質量%未満含み、残部が実質的に銅及び不可避不純物からなる銅合金鋳塊に圧延、溶体化処理及び時効処理を施して展伸材を製造するに際して、該銅合金の最終溶体化処理後の結晶粒度を0.005mm以上0.035 mm未満にすることを特徴とする銅合金展伸材の製造法。

【請求項３】上記銅合金を連続熱処理設備にて溶体化処理を行う場合、最終溶体化処理の条件を、加熱温度が９２３Ｋ（６５０℃）以上１１２３Ｋ（８５０℃）未満で10秒以上300秒未満に加熱した後、２００Ｋ/秒以上の冷却速度で急冷することを特徴とする請求項２記載の銅合金展伸材の製造法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、チタンを0.5質量%以上5.0質量%未満含み、残部銅及び不可避不純物からなる銅合金展伸材、及び鋳塊に圧延、溶体化処理及び時効処理を施して銅合金展伸材を製造する方法に係り、更に詳しく述べるならば、異方性が少なくかつ曲げ加工性の優れた銅合金展伸材を提供するものである。

【０００２】

【従来の技術】チタンを含んだ銅合金（以下「チタン銅合金」と言う）は、時効析出型の銅合金として材料特性の中でも特に強度及び応力緩和特性が優れているため、電子部品や端子･コネクター部品の分野において広く使用されてきている。該銅合金は、溶解鋳造によって鋳塊を製造すると、その後に熱間及び冷間加工、熱処理などの加工が施され、一部の材料については更にめっき等の表面処理を施されて、所定の特性及び形状にした後、部品に加工される。チタン銅合金に含まれるチタンは過飽和固溶体から分離され、Cu_3Ti相への中間相生成によって時効硬化を起こすものと考えられている。上記特性のほかにチタン銅合金は耐熱性が高力ベリリウム銅と比べて優れていることも特長である。従って、板･条材に打ち抜き加工や曲げ加工を施して電子部品や端子･コネクター材料として広く使用されている。

【０００３】一方、展伸材を製造する際には、特に溶体化処理や時効処理条件によって、その後の加工性や材料特性が大きく異なる。溶体化処理では、その条件によって過飽和固溶体からの析出は核生成を必要としないスピノーダル分解が生じ、特性が大きく変化する。スピノーダル分解は、材料内部に存在する溶質濃度のゆらぎが生じると、系の自由エネルギーは過飽和固溶体としてのエネルギーよりも低く、相分解は自発的に進行して臨界核を形成しない。すなわち、材料内に一旦小さい濃度変動が生ずれば、次々に大きな濃度変動に変化していき最終的には2相に分離する。スピノーダル分解が起こると材料特性が大きく変化するが、この分解は急激に進行する。

【０００４】従って、熱間圧延や溶体化処理を行った後にスピノーダル分解が生じる前に材料を冷却しておくことが出来れば、その後の加工が容易になるばかりでなく、材料特性ばらつきが小さくなって品質が安定するため、チタン銅合金の溶体化処理に関して、特性のばらつきが小さく、かつその後の加工が容易になる冷却条件で処理することは必要となる。また、チタン銅合金を時効処理した後に部品加工する際に異方性を少なくして曲げ加工性を向上させる必要がある。

【０００５】

【発明が解決しようとする問題点】しかしながら、従来は異方性に及ぼす製造工程条件のうちどの因子が最も影響が大きいかが把握されていなかったので、曲げ加工性は不充分であった。本発明者らの研究と実験によると、溶体化処理冷却条件及び溶体化処理による材料の結晶粒度がその後の材料特性に大きく影響を及ぼしていることが判明した。本発明は係る点に鑑みて為されたものであり、異方性を少なくして部品加工の際の曲げ加工性の優れた銅合金展伸材を提供するものである。

【０００６】

【課題を解決するための手段】本発明の要旨とするところは次の如くである。

（１）チタンを0.5質量%以上5.0質量%未満含み、残部実質的になる銅及び不可避不純物からなる銅合金に圧延、溶体化処理及び時効処理を施して製造され、最終溶体化処理後の結晶粒度が0.005 mm以上0.035 mm未満であり、時効処理後８００Ｎ/ｍｍ²以上の引張り強さを有し、圧延平行方向と圧延垂直方向の引張り強さの差で表される異方性が３０Ｎ/ｍｍ²以下と少なく、曲げ加工性が優れたことを特徴とする銅合金展伸材。

（２）チタンを0.5質量%以上5.0質量%未満含み、残部が実質的に銅及び不可避不純物からなる銅合金鋳塊に圧延、溶体化処理及び時効処理を施して展伸材を製造するに際して、銅合金の最終溶体化処理後の結晶粒度を0.005 mm以上0.035 mm未満にすることを特徴とする銅合金展伸材の製造法。

（３）上記銅合金を連続設備にて溶体化処理を行う場合、最終溶体化処理の条件を加熱温度が９２３Ｋ（６５０℃）以上１１２３Ｋ（８５０℃）未満で10秒以上300秒未満に加熱した後、２００Ｋ/秒以上の冷却速度で急冷することを特徴とする銅合金展伸材の製造法。

【０００７】すなわち、上述のように、チタンを0.5質

量%以上5.0質量%未満含み、残部銅及び不可避不純物からなる銅合金展転伸材において時効処理後の引張り強さが８００Ｎ/ｍｍ²未満であると、強度が不足し、また圧延平行方向と圧延垂直方向の引張り強さの差で表される異方性が３０Ｎ/ｍｍ²を超えると、異方性が大きくなり、曲げ加工性が優れないめに、本発明においては、時効処理後８００Ｎ/ｍｍ²以上の引張り強さを有し、圧延平行方向と圧延垂直方向の引張り強さの差で表される異方性が３０Ｎ/ｍｍ²以下と限定した。かかる優れた展伸材の等方性と高強度は、従来材では得られないものであり、これは中間工程の結晶粒度（最終溶体化処理後の結晶粒度）と関係している。なお、最終的結晶粒度は、後工程の処理の影響によって、中間工程の結晶粒度に対し多少増減するが、異方性には重大な影響を及ぼさない。

【０００８】次に、本発明において，チタンを0.5質量%以上5.0質量%未満を含み、残部実質的に銅及び不可避不純物としたのは、チタンの添加量が0.5質量%未満になると強度など優れた特性が得られず、5.0質量%以上になると材料が硬化して加工性の優れた材料が得られないためである。なお、チタンに加えて、総量で１．０質量%以下のクロム，ジルコニウム、ニッケル、鉄などを添加しても同様の効果を期待することができる。該銅合金の最終溶体化処理後の結晶粒度を5μm以上35μm未満としたのは、結晶粒度が0.005 mm未満になると、冷間加工などの前加工の影響が残存して、十分な加工特性をもつ展伸材が得られないためであり、該結晶粒度が0.035 mm以上になると部品加工する際に異方性が大きくなり、曲げ加工性が著しく劣るためである。

【０００９】また、連続熱処理設備を用いて溶体化処理を行う場合は、最終溶体化処理の条件を、加熱温度が９２３Ｋ（６５０℃）以上１１２３Ｋ（８５０℃）未満で10秒以上300秒未満に加熱した後、２００Ｋ/秒以上の冷却速度で急冷することが好ましい。加熱温度が９２３Ｋ（６５０℃）未満であると、300秒以上の加熱でも上記結晶粒度が得られず、１１２３Ｋ（８５０℃）以上であると、その温度に達すると直ちに粒成長して上記結晶粒度の材料を得るためには制御が困難になる。更に、溶体化処理後の冷却速度を２００Ｋ/秒以上としたのは、２００Ｋ/秒未満の冷却速度で冷却すると、冷却時にスピノーダル分解が生じて材料が硬化するためである。なお、２００Ｋ/秒以上の冷却速度を達成するには、水冷若しくは気水噴霧による冷却によって得られる。

【００１０】

【作用】本発明によれば、チタン銅合金の最終溶体化処理後の結晶粒度を0.005 mm以上0.035 mm未満にすると、部品加工した際の異方性を少なくし、曲げ加工性の優れた特性を有する材料を提供することが可能となる。

【００１１】

【実施例】供試材として用いたチタンを所定質量%含有したチタン銅合金の成分を表1に示す。所定の成分に配合されたチタン銅合金の鋳塊3.5ｋｇ（30ｍｍｔx120ｍｍwx100ｍｍl）を真空溶解炉内で溶製し、押し湯部を切断した後に表面皮むきを行う。皮むきされた鋳塊は、大気中で１１２３Ｋ（８５０℃）で1時間均質化焼鈍を行った後に27mm厚から所定の厚さ（通常は8mm厚）まで熱間圧延を行う。圧延中は2色式輻射温度計で材料表面温度を測定し、所定の温度になったところで水冷した。

【００１２】

【表１】

試験に用いたチタンを所定質量%含有した銅合金の成分

		成分（wt%）	
		Ti	銅
1	チタン銅 ①	1.5	残
2	チタン銅 ②	3.0	残
3	チタン銅 ③	4.5	残
比較			
4	チタン銅 ④	0.4	残
5	チタン銅 ⑤	6.0	残

【００１３】比較合金であるチタン銅 ④ は、最終時効処理まで行ったが、必要とされる特性（引張り強さ800 N/mm²、伸び２%以上）が得られなかった。比較合金であるチタン銅 ⑤ は、熱間圧延の際に割れが発生し、その後の加工が困難になった。

【００１４】更に、１１７３Ｋ（900℃）で1時間溶体化処理をした後に、再度表面皮削りを行い、冷間圧延にて7.5mm厚から1.0mm厚にする。次に、加熱･冷却速度を任意に変更できる装置を用いて所定の温度で所定時間加熱し、種々の冷却条件で冷却する最終溶体化処理を行い、その後に伸銅品の結晶粒度試験方法（JIS H0501）に従って評価した。更に材料厚さ0.3mmまで冷間圧延を施して、６７３Ｋ（400℃）で4時間時効処理を施した。なお、熱処理中の材料温度は接触式の熱電対を材料の熱処理部分に装着して試験中の材料温度を連続的に測定し、種々の冷却速度は水冷、汽水噴霧、空冷の水量、ガス流量を調整することによって行った。その後、材料の圧延に平行及び垂直方向の引張り試験を行って異方性を調査すると共にくり返し曲げ試験によって曲げ性を評価した。

【００１５】図１（表２）には、供試材の最終熱処理条件を示す。また、図２（表3）には、引張り試験及び繰り返し曲げ試験を行った試験結果を示す。引張り試験はN=３の平均値を示す。90°繰り返し曲げ試験は、曲げ半径R=0.3mmで（板厚0.3mm）破断までの回数で評価した。表中の“破断”は1回目の曲げ加工で破断した。表３より明らかなように、本発明にて製造した方法によって、異方性が小さく、また繰り返し曲げ性も優れた該銅合金を製造することが可能となった。

【００１６】

【発明の効果】本発明によれば、異方性が小さく、また繰り返し曲げ性も優れた該銅合金を製造することが可能となる。

【図面の簡単な説明】

＊【図１】　供試材の最終熱処理条件を示す図表（表２）である。

【図２】　引張り試験及び繰り返し曲げ試験を行った試験結果を示す図表（表３）である。

【図１】

表２ 供試材の最終熱処理条件

		加熱温度 K（℃）	加熱時間（秒）	急冷時の冷却速度（K/秒）	溶体化処理後の結晶粒度(μm)
1	チタン銅 ①	1023(750)	20	1000	10
2	チタン銅 ①	973(700)	120	800	10
3	チタン銅 ②	1073(800)	100	1000	20
4	チタン銅 ②	1073(800)	15	1000	10
5	チタン銅 ②	1073(800)	120	1000	30
6	チタン銅 ②	1023(750)	30	800	10
7	チタン銅 ②	953(680)	250	800	10
8	チタン銅 ③	1073(800)	60	800	20
9	チタン銅 ③	1023(750)	100	1000	20
10	チタン銅 ③	953(680)	250	800	10
比較					
10	チタン銅 ①	873(600)	250	1000	5<
11	チタン銅 ②	893(620)	250	800	5<
13	チタン銅 ②	1173(900)	100	1000	40
14	チタン銅 ②	973(700)	10	1000	5<
15	チタン銅 ③	1073(800)	600	800	40

【図２】

表３ 引っ張り試験及び繰り返し曲げ試験

		溶体化処理後の結晶粒度（μm）	引張強さ（N/mm²）		90°繰り返し曲げ（回）	
			平行方向	垂直方向	平行方向	垂直方向
1	チタン銅 ①	10	870	890	3	2
2	チタン銅 ①	10	920	930	3	2
3	チタン銅 ②	20	900	910	4	3
4	チタン銅 ②	10	910	920	3	2
5	チタン銅 ②	30	880	900	4	4
6	チタン銅 ②	10	960	970	3	2
7	チタン銅 ②	10	920	940	3	2
8	チタン銅 ③	20	980	1000	3	2
9	チタン銅 ③	20	1000	1030	1	1
10	チタン銅 ③	10	1050	1070	1	1
比較						
10	チタン銅 ①	5<	920	970	1	破断
11	チタン銅 ②	5<	970	1030	1	破断
13	チタン銅 ②	40	880	920	2	破断
14	チタン銅 ②	5<	1000	1050	破断	破断
15	チタン銅 ③	40	950	1020	1	破断

フロントページの続き

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		６９２			６９２Ａ